

Goals of the Mustard Project:

- ◆ Produce at least 6 billion gallons of mustard oil biodiesel
- ◆ Mustard oil biodiesel total production costs <\$1.00/gallon of pure biodiesel
- ◆ Displace synthetic pesticide chemicals with safer organic compounds



THE PROBLEM:

- ◆ If crop oils are available at 10 cents per pound or less, biodiesel could be made for \$1.00 per gallon of B100 (pure biodiesel).
- ◆ To get the value of the oil down below market prices, the oil must be inedible for humans as well as animals.
- ◆ For the oil seed crusher to make money when the oil is nearly worthless, the meal must have a higher value than animal feed.
- ◆ There must be a large industrial market for the meal that drives demand for the crop to produce enough oil to make a national impact on oil supply.

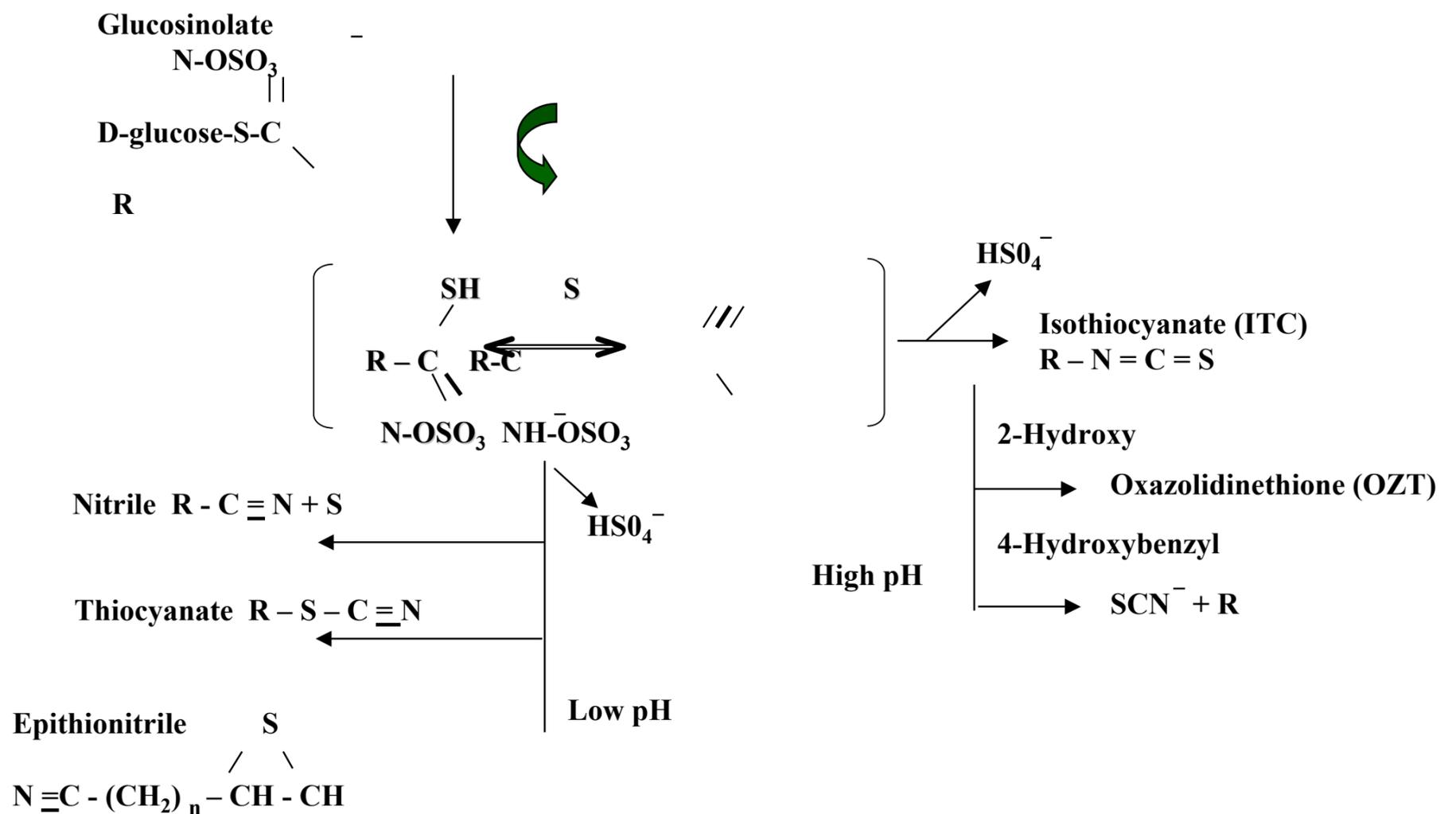
WHY ORGANIC PESTICIDES?

- ◆ Sustainable
- ◆ Internationally competitive
- ◆ Environmentally friendly
- ◆ Fewer commercial chemicals available
- ◆ High value market
- ◆ Expanding markets worldwide

ORIGIN OF THE IDEA:

- ◆ Mustard crops have been used as a green manure for hundreds of years. Mustard has been grown to a pre-seed state then plowed down for pesticide control.
- ◆ The active chemicals in the roots, stems and leaves that provide the pesticide effect are glucosinolates.
- ◆ Actually, the pesticide compounds are the breakdown products of glucosinolates: isothiocyanate, oxazolidinethione, 4-hydroxybenzyl, nitriles, thiocyanates, ...
- ◆ The glucosinolate content of the leaves, stems, and roots range from 5 to 20 $\mu\text{moles/gram}$.
- ◆ The glucosinolate content of the seeds range from 90 to well over 250 $\mu\text{moles/gram}$.
- ◆ We hypothesized that the meal would be a more effective pesticide than the entire plant used as green manure.
- ◆ Early trials with mustard meal as a pesticide were uninspiring, the effect was too dilute to achieve the desired effect on the target pest populations.
- ◆ **NO ONE EVER CONSIDERED INCREASING THE GLUCOSINOLATE CONTENT OF THE MEAL TO MAKE THE MEAL MORE EFFECTIVE!**
- ◆ NREL and its contractor, the Univ. of Idaho are breeding hybrid mustard varieties that show that the glucosinolate content of the meal can be increased by 5x or more, thereby, increasing the effectiveness per pound of product.
- ◆ The glucosinolate breakdown products have a half life of 48 hours and break down into soil nutrients.
- ◆ Mustard meal can be a safer, more environmentally benign compound to use compared to methyl bromide and other farm chemicals.

Glucosinolate Breakdown



PREVIOUS LABORATORY STUDIES

- ◆ ITC, OZT, and SCN^- display major inhibition effects on several hundred types of pests
- ◆ 100% inhibition for various types of glucosinolates and various pests for different exposure periods
- ◆ Inhibits seed germination and biomass growth
- ◆ Some toxicity to dormant seeds
- ◆ Some water soluble extracts effective, some not
- ◆ Effect depends on the glucosinolate type and the pest vector

PREVIOUS FIELD TRIALS

- ◆ Glucosinolate bearing tissues (biomass, seed meal) often not potent enough compared to synthetic pesticides
- ◆ Low glucosinolate content of native species
- ◆ Low target glucosinolates in some species
- ◆ Low release efficiency of ITC
- ◆ Residual impacts on cash crops
- ◆ Breakdown products occurred quickly and dissipated rapidly
- ◆ Half lives of 24-100 hours in most cases.
- ◆ Some breakdown products susceptible to leaching and volatilization
- ◆ ITC formation and activity is diluted by organic matter

RENEWABLE DIESEL MUSTARD RESEARCH PROGRAM

- ◆ Both fall-planted and spring-planted mustard hybrids are under development.
- ◆ Laboratory breeding program to develop first generation hybrids of mustard-rape seed or mustard-mustard varieties with high glucosinolate seed. (Fall 1999, Spring 2000, continuing)
- ◆ Second generation seed greenhouse grown for seed production. (Summer 2000, continuing)
- ◆ Third generation seed grown in field head-rows for seed production and agronomic data. (Fall 2000, continuing)
- ◆ Fourth generation seed grown in multiple locations for agronomic data. (Fall 2001)
- ◆ Seed varieties are eliminated for low glucosinolate content, low seed yield, poor agronomic character, oil content that does not meet biodiesel criteria. (continuously)
- ◆ By fall 2002, enough seed will be available for pesticide field trials in 2003 with our own varieties. Some laboratory and field trials for pesticide activity have started this year with suboptimal mustard seeds (not high glucosinolate seeds ~250 μ moles/gr) for data collection.
- ◆ Some limited field trials start this year with partners - potato, strawberry, foliage, nursery trees - with suboptimal seed for data collection.
- ◆ Some release efficiency trials are underway.
- ◆ Pesticide registration will be initiated in 2002.

Returns to the Farmer

	Quantity per Acre	Unit	Price or cost \$ per unit	Value or Cost \$ per Acre
Gross Returns				
Mustard	1100	lb	0.12	132
Total Gross Returns For Mustard				132
Operating Costs				
Custom Operations:				
Sprayer	1	acre	1.5	1.5
Pesticide:				
Roundup	16	oz	0.35	5.6
Fertilizer:				
Nitrogen	80	lb	0.21	16.8
Phosphate	10	lb	0.25	2.5
Sulfur	10	lb	0.18	1.8
Seed:				
Mustard seed	10	lb	1.25	12.5
Other:				
Crop Insurance	1	acre	3.6	3.6
Labor (machine)	1.52	hrs	13.3	20.28
Labor (non-machine)	0	hrs	0	0
Fuel - Gasoline	2.06	gal	1.5	3.09
Fuel - Diesel	7.82	gal	0.9	7.04
Lube				1.52
Machinery repair				5.96
Interest on operating capital @ 9.75%				3.98
Total Operating Costs/acre				86.16
Net Returns Above Operating Costs				45.84

Returns to the Crusher

Soy Beans			Value \$	Revenue
			per unit	per bu
1bu contain:			6.83	
beans	60	lbs/bu	0.11	
oil	11.05	lb/bu	0.255	2.82
meal	47.48	lb/bu	0.11	5.00
losses	1.47	lb/bu	0	
Total				7.82
Revenues - feedstock cost			0.99	per bu
Mustard Seeds				
			Value \$	Revenue
			per unit	per bu
1bu contain:			6.6	
seeds	60	lbs/bu	0.11	
oil	23.25	lb/bu	0.1	2.33
meal	35.25	lb/bu	0.15	5.29
losses	1.5	lb/bu	0	
Total				7.61
Revenues - feedstock cost			1.01	per bu

RECENT ACCOMPLISHMENTS

- ◆ Developed hybrids with more than 500 μ moles glucosinolates per gram of seed meal, concentration appears to be additive
- ◆ Developed hybrids with high levels of specific types of glucosinolates with high activity in producing specific (ITC, OZT, SCN-) breakdown products
- ◆ Isolated a variety with 90% monounsaturated oil for cross-breeding back into the high glucosinolate varieties
- ◆ Many varieties meet the eurcic acid requirement of greater than 2% but less than 20%
- ◆ Identified 12 or more varieties that could produce more than 2 tons per year per acre seed
- ◆ Many varieties are drought tolerant and have been produced on wheat land without irrigation in N.W. Idaho
- ◆ Economics of mustard seed production looks promising Univ. of Idaho, Cooperative Extension Service, EBB1-YM-99, Yellow Mustard Seed. S. Berglund et al.